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TREATED COTTON FABRICS

Unit No. 337

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TREATED COTTON FABRICS

This unit of THINGS of science contains six specimens of treated cotton fabrics, six cotton control fabrics, a cable of stretch cotton yarn and a magnifier.

Fabrics woven from cotton fibers have been in existence since before the Christian era, and for most of us today, they are still an important and indispensable commodity. A quick glance around your home will reveal to you how much we depend upon cotton for our daily needs and comfort. In many textile uses, there is no suitable substitute for cotton because of its absorbing power, washability and other characteristics with which you are all familiar.

Through the years, cotton fabrics have been created in a variety of weaves, from the most delicate voiles to the heaviest canvases. But until recently attempts to add new and different properties to cotton cloth were not seriously undertaken.

As a result of the expansion in the manufacture of man-made fibers and the production of synthetic fabrics possessing unusual and desirable properties not found in natural cotton fibers, such as wrinkle and water resistance, it became essential for the cotton industry to provide similar qualities in cotton materials

if it wished to maintain its lead in the textile field.

For this reason and also in order to improve cotton properties to meet the increasing demands of the present-day world, extensive research has been carried on by various textile researchers, and particularly by the Southern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, in New Orleans, La., who provided the fabric specimens and cables of all-cotton stretch yarn in this unit. The samples are examples of some of the results of their efforts toward the broader utilization of cotton fabrics.

You will observe and test properties, such as wash-wear, stretch, water and oil resistance, flame retardation and rot resistance, with the materials and learn something of the intricate chemistry involved to achieve these characteristics.

First examine your specimens.

COTTON MATERIALS—Set of 12 swatches stapled together consisting of six control and six treated fabrics. Remove the staple and note that there are two of each color.

STRETCH YARN—Cable of cotton yarn about 12 inches long.

MAGNIFIER—Plastic magnifier.

Cotton still remains the most popular fiber for household uses and clothing. To keep pace with man-made fibers, studies were made to see which qualities were most sought in cotton textiles by consumers. Research has been directed to provide the desired properties and some of the products are now commercially available while others are still at the laboratory level.

To impart these properties to the fabrics, cotton is treated with different chemicals that either coat the fiber and adhere to it, change the physical and chemical nature of the fiber itself or combine with it chemically.

The experiments following will show you how successful some of the research has been in imparting new qualities to the fabric while causing no impairment of the cotton material itself or change in its intrinsic nature.

Examine your swatches of fabric. Pair the similarly colored pieces. Note that the weave and thread size are similar in all the specimens with the exception of the olive drab material which is a twill.

In each pair of colors, one is the control and the other the treated material. You will be able to distinguish which

is which by doing the experiments outlined.

OIL AND WATER REPELLENT FABRIC

One of the very useful finishes that has been developed is a treatment that is deposited on the surface of the fibers and provides oil and water repellency to cotton fabrics.

If water or oil is spilled on lightweight cotton fabrics used in everyday garments, no real problem is created since cotton materials wash and dry readily. However, in many cases frequent washing is neither easy nor practical as with outdoor clothing, overalls, and furniture coverings. Here an oil and water repellent material would be very desirable.

Experiment 1. Take your two pieces of white cloth and examine them with your magnifier noting the weave and size of yarn. Are the two pieces similar? Feel the fabrics. Can you tell by touch which has been chemically treated and which not? You will find that it is just about impossible to distinguish the control from the treated cloth by such means.

Experiment 2. Place the two specimens side by side on a flat surface that will not be damaged by oil or water. Put a drop of water on each. What happens?

The water is quickly absorbed by one sample, while on the other it forms a spherical drop. The formation of the spherical drop indicates that the water is repelled. Now you have identified the treated specimen, and you know it repels water.

Blot the excess water off both fabrics without using pressure with absorbent tissue or a soft cloth. Feel both samples. The control is wet but the treated cloth is dry. The water does not penetrate the treated fabric at all.

(Cut a one-half inch wide strip from the treated cloth and label it and set it aside for comparison purposes. Do the same for each of the other treated specimens as they are identified.)

Experiment 3. Now drop a little cooking or vegetable oil on both the control and treated specimens. Does the treated fabric repel oil also? Blot or shake the excess oil away being careful not to rub it in. Hold both specimens up to the light. Do you see an oil stain in both fabrics? The treated cloth does not absorb oil.

To provide oil and water repellency, the fabric is treated with a fluorochemical, a complex organic compound. The fluorochemical finish is applied after the

yarn has been woven into cloth and provides an impenetrable surface that prevents oil and water from reaching into the fibers.

Experiment 4. Place another drop of the oil on the treated cloth. This time rub the oil in. Does the oil penetrate the cloth?

Oily and greasy products should be removed from a garment by blotting. Rubbing causes the oil to penetrate into the cloth and makes removal more difficult.

Experiment 5. Wash both samples in the same manner and for an equal length of time in hot water with soap or detergent and then allow them to dry. Does washing remove the oil stain from both materials? If not, which sample retains the oil stain? The treated material releases oil more readily.

Experiment 6. Drop a little coffee or tea on both materials. Then a fruit juice such as grape juice. Which sample is most readily stained?

The treatment to provide oil and water repellency imparts a resistance also to water-borne stains.

Experiment 7. Wash both cloths.

Which specimen releases stains with greater difficulty?

Experiment 8. After the specimens have been dried, does one of the fabrics appear more wrinkled than the other? The treatment for oil and water repellency also provides some wrinkle resistance to the fabric.

Experiment 9. Cut a ¾ x 2-inch piece from the treated cloth and wash this piece a number of times. Then test again for oil and water repellency.

Do these properties decrease with repeated washings? How many washings can the oil and water resistant qualities survive?

Experiment 10. Boil a similar size piece of the treated material in water for about 10 minutes. What effect does this have on the oil and water repellent powers?

The water and oil resistant property of the fabric gradually deteriorates with repeated laundering and high temperatures hastens the decrease in effectiveness. The repeated washings eventually cause the surface treatment to wear away.

Water repellent fabrics are different from waterproof fabrics. When a fabric

is waterproofed, the spaces between the yarn are sealed with a coating so that air and water vapor cannot pass through the fabric, but in water repellent fabrics the spaces between the yarns remain open, allowing free passage of air and water vapor.

Garments made of waterproof fabrics, therefore, are less comfortable than those made from water-repellent fabrics. Waterproof fabrics are preferred for uses such as awnings and beach umbrellas.

OIL REPELLENT FINISH

A fabric that is both oil and water repellent is useful for many purposes, but in most fabrics water resistance is not too desirable because the material becomes difficult to launder. The water is repelled and cannot penetrate the material sufficently to reach the soiled areas.

A finish that is oil resistant without being water repellent was therefore developed.

Experiment 11. Take your pink specimens and examine them with your magnifier. Feel the material. Compare the material with the fabric treated for both oil and water resistance. Do you see any differences?

The finish used on your pink fabric is a fluorine-containing compound also, but other chemicals in carefully determined amounts were added during the processing to reduce water repellency without decreasing oil resistance.

Experiment 12. Place a drop of vegetable oil on both pink fabrics. By observing your results you should be able to tell which is the control and which the treated material.

Experiment 13. Put a drop of water on each specimen. What do you find?

Fabric treated with the oil repellent finish does not wet as easily as the untreated fabric but it is much less hydrophilic or water-attracting than the material with the oil and water repellent finish.

Experiment 14. Dip an edge of the unused treated white oil and water repellent fabric and an edge of the treated pink fabric in warm water for a minute or so. Then remove and shake or blot off the excess water. Which specimen is more hydrophilic?

Experiment 15. Drop a little oil again on both the control and treated pink fabrics. Rub the oil droplet into the

fabrics. Now wash both for exactly the same period in warm water containing soap or detergent. Observe your results. What are your conclusions?

Experiment 16. Stain both fabrics with coffee, tea or fruit juice. Then wash them. Does the oil repellent finish repel stains as well?

WASH-WEAR FINISH

Among the most popular of the new cottons is the wash-wear fabric which helps reduce the hours of ironing for the housewife. The development of this type of finish has helped retain markets for more than one million bales of cotton annually. This amounts to about 10% of the cotton consumed in the United States each year.

Wrinkle resistance in cotton textiles was originated in studies by Foulds, Marsh and Wood of Tootal Broadhurst Lee Co. in the 1920's but it was only in 1956 that major efforts were begun in this field, stimulated by the increasing competition exerted by man-made fibers.

Although you cannot see any difference between the control and treated cloth by looking at them through the

magnifier, chemically there is a significant difference in the fibers.

To produce wrinkle resistance the cotton cloth, while the fibers are wet and swollen, is treated with a chemical that produces a reaction known as crosslinking in the cellulose that makes up the cotton fibers.

In crosslinking, the long cellulose molecules are linked with other cellulose molecules. This crosslinking imparts "memory" to the fabric so that the fabric treated while flat and smooth, will always return to this condition regardless of how creased and wrinkled it may become.

Memory is imparted to the cotton by treatment with low molecular weight chemical compounds such as formaldehyde. The compound penetrates the fiber and causes crosslinking of the cellulose molecules. If many adjacent molecules become linked together, the fabric exhibits good wrinkle resistance, wet or dry.

Experiment 17. Produce wrinkles in both specimens of blue material by crumpling them in your hand. Does one specimen become more wrinkled than the other? The less wrinkled sample is the wash-wear fabric.

Wash-wear fabrics show some resistance to dry wrinkling.

Experiment 18. Wash both materials in soap or detergent. Then hang them up to dry. Upon drying one specimen is full of wrinkles and the other smooth and wrinkle-free. Wash-wear fabrics dry smooth and do not usually have to be ironed, but if ironing seems to be required it can be quickly accomplished. Does your specimen need ironing?

Wash-wear materials also show little shrinkage and dry quickly. When tumble dried, garments made of wash-wear materials dry in about half the time required to dry untreated cottons.

Fabric treated for wrinkle resistance may be dry cleaned or laundered. Most white goods are not adversely affected by bleaches.

Experiment 19. See how many washes the wash-wear quality can survive.

Wrinkle resistance gradually deteriorates with repeated laundering.

ROT RESISTANCE

Cotton textiles used for outdoor purposes as in awnings, tents and tarpaulins,

gradually deteriorate until they must finally be replaced. This decay or rotting of the material is the result of constant exposure to the sun's rays and also, in very humid areas, to molds and fungi.

To counteract rot, cotton fabric is treated with a colorless chemical, trimethylolmelamine. This chemical gives the fabric a weather-resistant finish that greatly increases the wear life of the material.

Experiment 20. The yellow fabrics are a control and rot resistant specimen. Feel them. As with the other specimens, you have observed that chemical treatment of the fabrics does not affect the hand (or the feel) of the material.

Experiment 21. Cut a ¾ x 2-inch strip from each of the specimens and bury them in damp soil such as a flower bed. Dig them up and observe them at one-week intervals. Shake off any dirt and note the effect of dampness and soil on the specimens.

The sample that is most damaged by exposure to these conditions of course is the control.

Untreated cotton will rot in a short time while treated cotton fabric will retain its strength for many weeks.

Experiment 22. Cut another piece from each of your specimens and place them outside where they will be exposed constantly to the sun and rain. Examine at one-week intervals. What changes take place in the materials? Which sample is affected the most?

Other chemical finishes such as zirconium-metal salt solutions which show antifungicidal properties and resistance to algae when exposed outdoors for long periods are under study.

SLACK MERCERIZED YARN

Cotton fibers do not have much elasticity. You can observe this by trying to stretch cotton sewing thread. Because of cotton's many other desirable properties and the many possible uses of a cotton stretch material, efforts to make such a fabric were undertaken. Stretch cottons are in wide use as a result of this research.

Many methods for making stretch yarns were investigated, but there are three main approaches: slack mercerzing yarns to produce shrinkage; setting the yarns in a crimped or coiled position by using crosslinking agents; and by heat setting cotton yarns that have been given thermo-

plastic properties by chemical treatment.

Specimens of the stretch cotton produced by the first two methods are included in this unit.

Experiment 23. One of the orange fabrics is a stretch cotton produced by the process known as slack mercerization.

Try to stretch the two pieces by pulling along the fibers lengthwise and then crosswise (not diagonally). Do you find that one of the specimens shows a stretch in one direction? You will have to observe this carefully to notice the stretch because the samples are small.

The fabric that stretches is a sample of slack mercerized cotton having one-way stretch. The other, the control, will stretch neither way.

Garments made with slack mercerized material will stretch with a person's movements to provide comfort, increased wear life, and aesthetic properties. Bathing suits, dresses and undergarments as well as automobile upholstery and furniture slipcovers can be made with this type of stretch material.

The slack mercerization process is simple. Cotton fabric is placed in a bath of sodium hydroxide solution and allowed to shrink without restriction at a tem-

perature of about 30°C or lower. Many changes occur in the cotton fiber during this treatment such as reduced fiber length, increased affinity for dyes, increased moisture absorption, increased fiber diameter and reduced density and crystalline content, but the desirable cotton properties are not lost.

The process can be varied to produce different stretch qualities. The amount of stretch acquired by the cotton fabric depends upon the type of weave and the amount of shrinkage that occurs during the process.

Experiment 24. Note that the treated cotton stretches in only one direction.

Slack mercerized fabrics generally have the stretch in the filling yarns. Although they can be made to have stretch in both the warp and filler.

The stretch in your specimen is in the filling yarn only.

When fabrics with filling stretch are being processed, the warp yarn is not allowed to shrink and is held under tension. No tension is exerted on the filler which is allowed to shrink freely. Shrinkage is usually about 20 to 30%.

To provide the greatest amount of shrinkage, the fabric to be slack mercer-

ized is usually loosely woven. The amount of filling stretch increases as the number of warp yarns per inch is decreased. Upon mercerization, the shrinkage results in a high thread count in the finished goods.

During mercerization, the smaller filler yarns tend to crimp around the larger warp yarns. This filling crimp is important in maintaining the elastic quality of the stretch yarn. The fabric must not only stretch, but it must be able to shrink again.

If the warp yarns are small and the filler yarns are large, then the filler yarns, instead of crimping around the finer warp yarns, push them aside and the result is less shrinkage and poor recovery.

The amount of stretch obtained is determined by the original length of the yarn and the amount of shrinkage occurring during mercerization.

Experiment 25. Using your magnifier note that the thread count in the treated and untreated fabrics are about the same.

Experiment 26. Remove single yarns from both the length and width of the fabric. Pull on each gently. Note that one of the yarns will stretch while the other

will not. The yarn that does not stretch is the warp and the one that stretches is the filler.

Most fabrics of conventional weave like your specimen have a stretch after slack mercerization of about 20%. However, for most apparel uses, 12 to 15% easy stretch with good recovery is considered adequate. About what percentage stretch do you judge your specimen shows?

When a slack mercerized fabric is repeatedly stretched, its recovery power gradually decreases and the fabric "grows." Most of this growth can be removed by laundering and drying.

Experiment 27. Stretch your fabric as far as it will stretch, without tearing, over the corner of your THINGS box and keep it under tension for about one-half hour. Then remove it. Note that growth has occurred in the material and the stretch area has a slight bulge.

Wash and dry the material. Does it become smooth again?

Stretch fabrics quickly regain their stretchability on washing. Slack mercerized cottons are usually used in wearing

apparel such as slacks, blouses, shirts, pajamas, skirts and sportswear where a high degree of stretch and recovery are not required and where stretch is for relatively short periods.

Slack mercerized fabrics include print cloths, sheeting, denims, twills, corduroy, broadcloth and ducks.

Two-way stretch fabrics may be made by slack mercerization by allowing both warp and filler to shrink freely, but present methods for producing such material are slow and relatively expensive.

ALL-COTTON STRETCH YARN

The second method of producing stretch cotton involves the treatment of the yarn with chemicals before weaving to cause crosslinking as is done in producing wash-wear fabrics.

The principle involved in this process is that cotton yarn treated with crosslinking resins tends to return to the shape it had when treated. Memory is imparted to the yarn as in wash-wear fabrics.

Two techniques have been studied to produce stretch utilizing crosslinking agents: falsetwisting and backtwisting.

The yarn in your unit was produced by falsetwisting.

The method provides a permanent texture in the form of helical coils to the yarn.

Experiment 28. Note the texture of your cable of stretch yarn with your magnifier. Observe the way in which the yarn twists around to form coils. Gently stretch the cable. Note how it springs back when released.

In falsetwisting, chemically impregnated plied yarn enters a spindle where it is twisted 25 to 50 or more turns per inch. The yarn is cured while in this false-twisted condition. As it leaves the spindle, it is restored to its original twist.

During curing, crosslinking takes place among the cellulose molecules and memory is imparted to the yarn. Thus, after the yarn is returned to its original twist, it tries to return to the falsetwist in which it was cured. In making this attempt, the yarn forms the helical coils.

Experiment 29. Holding the two ends of the cable slowly untwist the coils so that the yarns are parallel. Then release one end. The yarn springs back quickly into its coils.

Experiment 30. Measure the length of your cable. Then stretch it as far as it will go and measure it again. Approximately what percent stretch is obtained?

By adjusting the amount of twisting and the quantity of chemicals used during the processing, manufacturers can regulate the elongation of the yarn. Stretch up to 200% is possible.

Cut off a single thread of the yarn and note its crimped appearance. Stretch it. Compare its stretching ability with a yarn from the slack mercerized sample.

The stretchability of the crosslinked yarn is due to the springlike helical coils and not the elasticity of the yarn itself as you can observe.

Experiment 31. Count the number of strands of yarn making up the cable. Take an equal number of short lengths of sewing thread of the same diameter as that of the stretch yarn and twist them into a cable. Compare the size of the two cables. Note how much bulkier the stretch yarn is.

Because of this bulkiness the weight per unit area of cloth made of stretch yarn is much less than that of fabric woven from regular yarn, and the texture of the yarn prevents the free flow

of air through the fabric. Since air is a much better insulator than fiber, cottons made from stretch yarn will provide warmth without increased weight making them useful for winter clothing.

The tendency of stretch fabrics to yield to pressure and their springlike resilience make them more abrasion resistant also.

Experiment 32. Immerse the cable in water and then stretch it. Allow it to dry. Does it return to its original length?

Experiment 33. Wind the cable around the THINGS box stretching it to its full length and secure with a paper clip or pin. Allow it to remain stretched for several days, then remove it. Does the yarn spring back? Allow it to relax for several days. Does it recover fully?

Experiment 34. Stretch it in the same way again and then wet it after removing it from the box. Does the yarn shorten immediately upon wetting?

Experiment 35. Wash and dry the yarn a dozen times or so. Does it return to its original length each time?

Most of the resins used to produce cotton stretch yarns show good durabil-

ity and do not deteriorate with washing. This is important since the stretch property is dependent upon the resin bonds.

Loss of the resin of course would alter the size and fit of a garment and if all the elasticity were lost, the garment would become useless.

FLAME RETARDANT FINISH

Many of the fabrics used in clothing and in decorating the home are made of combustible materials and fire hazards associated with their use have stimulated research to produce durable flame retardants for textiles.

In modern warfare the use of incendiary weapons has emphasized even more the importance of developing fire retardant textiles.

A satisfactory flame retardant for cotton must be, among other requirements, durable to laundering and dry cleaning, resistant to chlorine bleach, able to form a tough char preserving the natural fiber characteristics when exposed to flame, non-irritating to the skin, glow resistant and reasonable in cost.

The fire retardant used in the fabric in your unit is one of the newest durable flame resistant finishes.

The fabric is wetted or padded in a solution of tetrakis (hydroxymethyl) phosphonium hydroxide, a little known chemical compound commonly called THPOH. It is then dried to about 20% moisture and finally exposed to ammonia vapors for curing. The process is known as the THPOH-NH_3 method.

The ammonia vapors react with the THPOH to form a highly insoluble flame resistant polymer which remains inside the individual cotton fibers for the life of the fabric.

This finish is suitable for lightweight as well as heavier weight fabrics and leaves the cloth almost as soft as untreated materials with little loss in fabric strength.

Experiment 36. The olive drab material is a twill similar to that used in military uniforms. Examine its weave with your magnifier.

Feel both specimens. Note that both fabrics are about equally soft.

Experiment 37. Cut a half inch strip from each of your specimens. DO THIS EXPERIMENT OVER A SINK OR BASIN OF WATER.

Apply a candle flame or a lighted long

kitchen type match (so you won't burn your fingers) to each of the materials.

One specimen burns readily and continues to burn after the match is removed, while the other fabric does not support a flame and stops burning as soon as the flame is taken away. Which is the treated specimen?

Experiment 38. Wash the treated material with hot water and soap or detergent and allow it to dry thoroughly. Apply a flame to the fabric again. Has it retained its flame retardant property? Repeat several times.

The flame retardant property does not diminish with laundering or dry cleaning but is maintained throughout the life of the fabric.

Experiment 39. Burn another piece of the treated cloth. Does it retain a glow? Note that as soon as you remove the flame, the glow disappears.

The flame retardant imparts anti-glow properties to the fabric.

Experiment 40. Apply a flame again to both specimens. Note that the untreated cloth burns away and is eaten up by the flame.

The treated fabric becomes charred but does not burn away and keeps its woven structure.

Experiment 41. Feel the charred material gently. Is it still pliable? Does it retain its shape without breaking apart under moderate strain? The treated fabric forms a relatively tough and pliable carbonaceous fabric.

Experiment 42. Tear the charred area. The charring caused weakness and brittleness in the material but did not affect the structure. This characteristic is especially important for the protection of a person exposed to high temperature or open flame.

Pull away one of the charred threads. Rub it between your fingers and note that it disintegrates into a black sooty residue. The charred treated fabric even though its yarns were so fragile maintained its shape.

Experiment 43. Hold a piece of both the control and treated materials about three inches above a flame. Compare the resistance of the two fabrics to

heat without actual contact with the flame.

A number of other durable flame retardants have been developed based on the use of other organic chemicals. Some are used commercially and some are still under study.

Appreciation is expressed to the Southern Utilization Research and Development Division, Agricultural Research Service, USDA, New Orleans, La., for their cooperation in preparing this unit.

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